Offshore Information for Area Contingency Planning

Offshore Worst Case Discharge Scenarios and Modeling

Arctic and Western Alaska ACP
Cook Inlet

Technical Document #2
Appendix 2A

May 2023

Record of Changes

Change Number	Change Description	Section Number	Change Date	Name
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1 Introduction

In 2019, the Bureau of Safety and Environmental Enforcement (BSEE) sponsored a project in cooperation with the United States Coast Guard (USCG) to improve the content of the coastal zone area contingency plans (ACPs) with respect to the information necessary to effectively plan for and respond to large oil spills from offshore oil and gas facilities. This collaboration between BSEE, the Bureau of Ocean Energy Management (BOEM), USCG Sector Anchorage, Alaska Department of Environmental Conservation (ADEC), resource trustees, state agencies, oil spill removal organizations (OSROs), and the Arctic and Western Alaska Area Committee resulted in a series of technical documents that provide offshore information on:

- Oil and Gas Infrastructure (Arctic and Western Alaska Technical Document #1)
- Worst Case Discharge Scenarios (Arctic and Western Alaska Technical Document #2 and Appendices 2A-C)
- Response Concept of Operations (Arctic and Western Alaska Technical Document #3)
- Response Strategies and BMPs (Arctic and Western Alaska Technical Document #4)
- Sensitive Species Profiles (Arctic and Western Alaska Technical Document #5).

These documents were developed specifically for incorporation by reference into the coastal zone ACPs and are hosted on the BSEE Oil Spill Preparedness Division's (OSPD) website.

The WCD scenario information in Technical Document #2 is organized into three main components: Section 2 contains a description of key modeling concepts and reference scales that are useful for understanding the oil spill trajectory data and figures that have been developed for each of the WCD scenarios. Section 3 contains a series of tables that collate and summarize key information regarding all of the WCD scenarios that were developed for Alaska. Appendices 2A – 2C contain specific, more detailed WCD scenario modeling data and trajectory figures for each of the regions in the Arctic and Western Alaska ACP Planning Area. Appendix 2A contains the modeling information for the two offshore WCD Scenarios in Cook Inlet.

2 Meteorological and Oceanographic Conditions in Cook Inlet

To understand the behavior of marine spills, it is necessary to analyze and evaluate the predominant environmental conditions in the area of interest. Winds and currents are the key forcing agents that control the transport and weathering of an oil spill. To reproduce the natural variability of the environment, the oil spill model requires wind and current datasets that vary both spatially and temporally. Optimally, the minimum window of time for stochastic simulations is 5 to 10 years; therefore, long-term records of wind and current data were obtained from the outputs of global numerical atmospheric and ocean circulation models for this modeling.

2.1 Wind Dataset – NCEP CFSR

Wind data (Table 1) were obtained from the U.S. National Centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR) for a 5-year period (2006 to 2010). CFSR winds were also one of the main driving forces used in the HYCOM Reanalysis, the global hydrodynamic currents dataset used in the modeling for Cook Inlet.

Table 1. The specifics of the wind dataset used for the modeling of Cook Inlet.

Name of Dataset	CFSR
Coverage	148 °W – 159 °W 56 °N – 61 °N
Owner/Provider	NCEP (US)
Horizontal Grid Size	0.31°x0.31°
Hindcast Period	2006 - 2010
Time Step	6 hourly

Figure 1 describes the variability of wind speed and direction near the spill sites based on the CFSR dataset. Near Hilcorp Exploration, the wind direction is predominately from the north-northeast and the wind speed is stronger compared to Cosmo A-1 across all the other directions. The annual CFSR wind rose near Cosmo A-1 shows the wind direction is predominately from the north-northeast. Wind speeds are presented in m/s, using meteorological convention (i.e., direction wind is coming from).

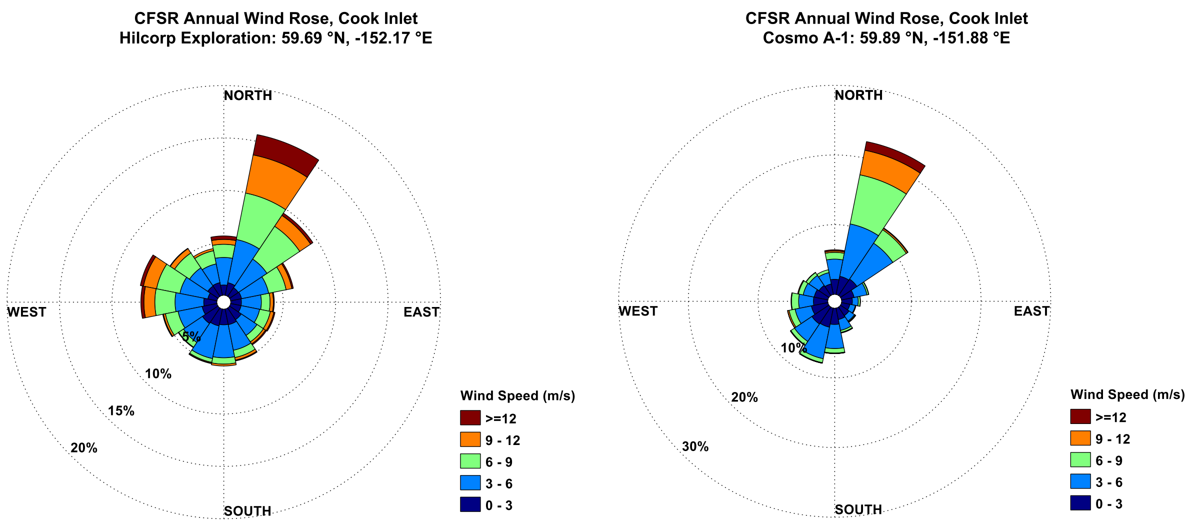

Figure 1. Annual CFSR wind rose near Hilcorp Exploration (left) and Cosmo A-1 (right) within Cook Inlet. Wind speeds are in m/s, using meteorological convention (i.e., direction wind is coming from).

2.2 Global Current Dataset – HYCOM Reanalysis

Current data was obtained from the HYCOM (HYbrid Coordinate Ocean Model) hindcast reanalysis, a 1/12-degree global simulation assimilated with NCODA (Navy Coupled Ocean Data Assimilation) from the US Naval Research Laboratory (Table 2). This dataset captures the oceanic large-scale circulation in Cook Inlet. Forcing for the model comes from the US National Centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR). Ocean dynamics, including geostrophic and wind driven currents, are reproduced by the model. The most recent reanalysis experiment (GLBu0.08/expt_19.1) includes data between August 1, 1995 and December 31, 2012.

Table 2. The specifics of the current datasets used for the modeling of Cook Inlet.

	Global	Regional Tidal
Coverage	148 °W – 159 °W 56 °N – 60.96 °N	~165 °W – ~116 °W 30 °N – 75 °N
Name of Dataset	HYCOM (GLBu0.08/expt_19.1)	HYDROMAP
Owner/Provider	Naval Research Laboratory (USA)	RPS
Bathymetry	GEBCO	GEBCO
Wind Forcing	CFSR (USA)	-
Tides	-	TPXO 7.2
Horizontal Grid Size	~9 km	0.6x1.15 km to 5x10 km
Hindcast Period	2006 - 2010	Periodic tidal constituents' phase and amplitude
Output Frequency	Daily	30-minute processing

2.3 Tidal Currents – HYDROMAP Tidal Model

A hydrodynamic model application of the Cook Inlet was developed for the purposes of generating spatially and temporally varying tidal current fields for use in the metocean analysis. The model application was developed using RPS' HYDROMAP model system. The model application was set up to determine tidal circulation only. The resulting tidal current speeds are presented in Figure 2 for Hilcorp Exploration and Figure 3 for Cosmo A-1. The two model current datasets (current components of HYCOM+HYDROMAP) were combined to produce a new, more accurate total steady current dataset to be used for all current analyses in this study.

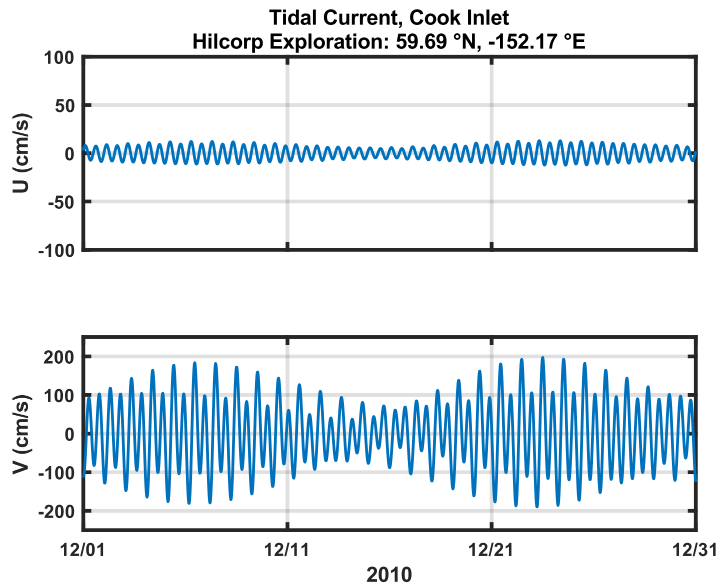

Figure 2. Example of a timeseries of the U and V components of the tidal current (from HYDROMAP) near Hilcorp Exploration.

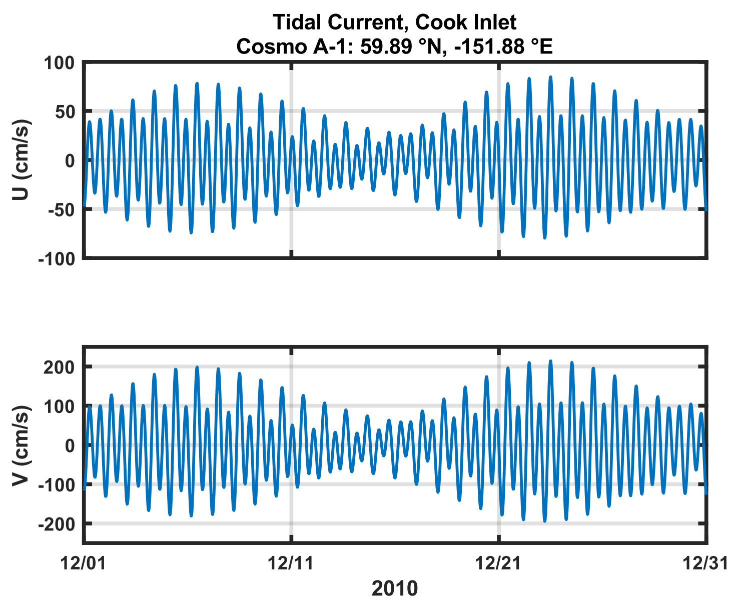

Figure 3. Example of a timeseries of the U and V components of the tidal current (from HYDROMAP) near Cosmo A-1.

3 Hilcorp Cook Inlet Exploration Surface Well Blowout

3.1 Scenario Description

The Hilcorp Cook Inlet Exploration WCD Scenario is a surface well blowout with the following key parameters

Table 3. Scenario Key Parameters.

Discharge Depth (m)	Distance from Shore (NM)	Oil Type	Spill Type	Ice Coverage	Discharge Duration (days)	Discharge Flowrate (bbl/day)	Total Oil Discharged (bbl)
Surface	12.2	Light Crude API = 38	Surface Well Blowout	Open Water	30	6,800	204,000

3.2 Potential Oil Contact with the Environment and Resources at Risk

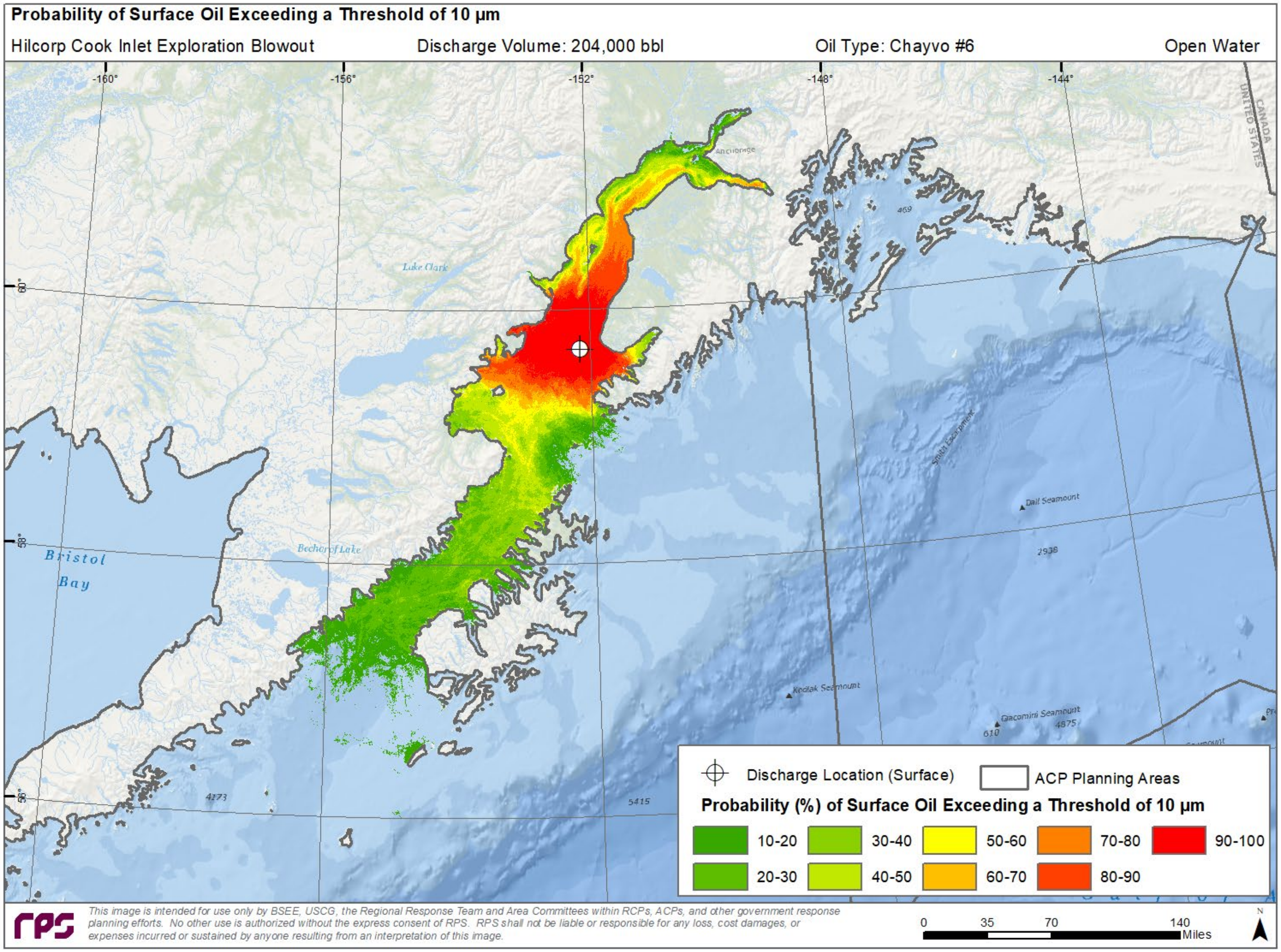

Figure 4. Probability Footprint for Oil on the Water Surface with Average Thickness greater than the Ecological Threshold of 10 µm.

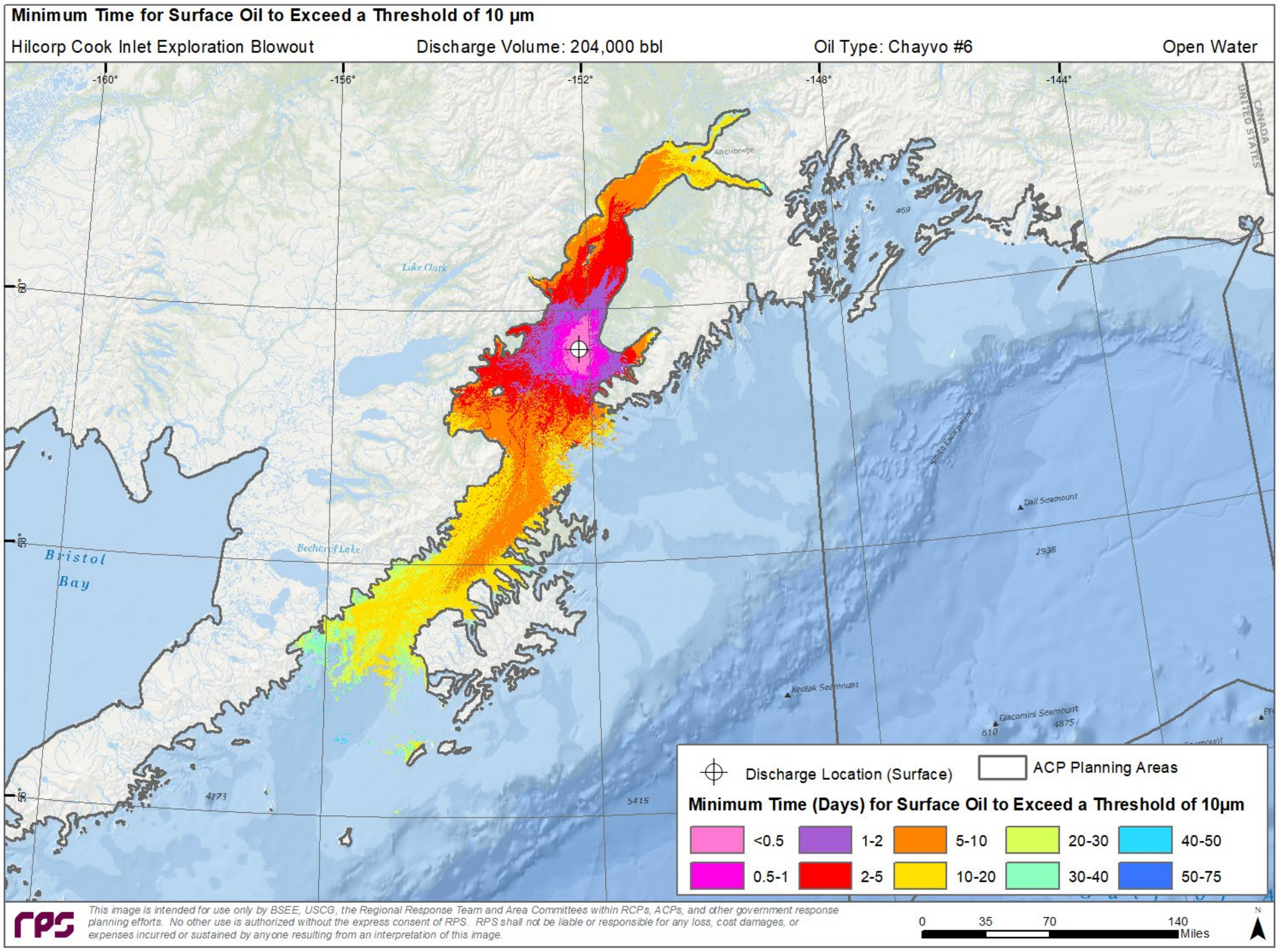

Figure 5. Minimum Time for Oil on the Water Surface with Average Thickness greater than the Ecological Threshold of 10 µm.

Table 4. Oil Spill Stochastic Results – Predicted Shoreline Impacts.

Percentage of Simulations Reaching shore (%)	Percent volume of discharged oil reaching shore (%)		Time to Reach Shore (hours)	
	Maximum	Average	Minimum	Average
100	18	11	12.0	59.8

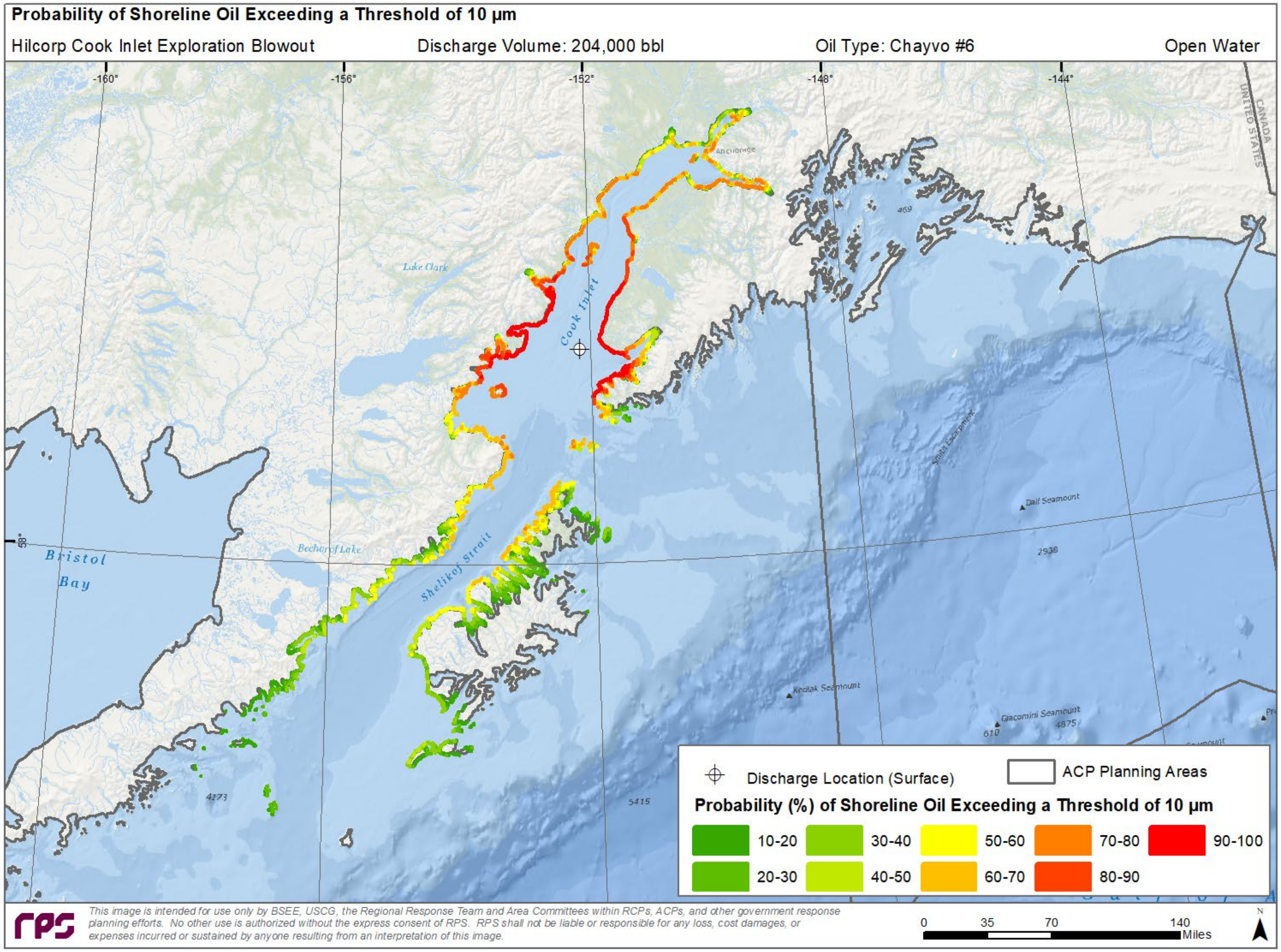

Figure 6. Probability Footprint for Oil on the Shoreline with Average Thickness greater than the Ecological Threshold of 10 µm. This thickness of oil may appear on the shore as dark stain or film. 10 µm is a conservative ecological screening threshold for potential sublethal effects on fauna and birds on the shoreline.

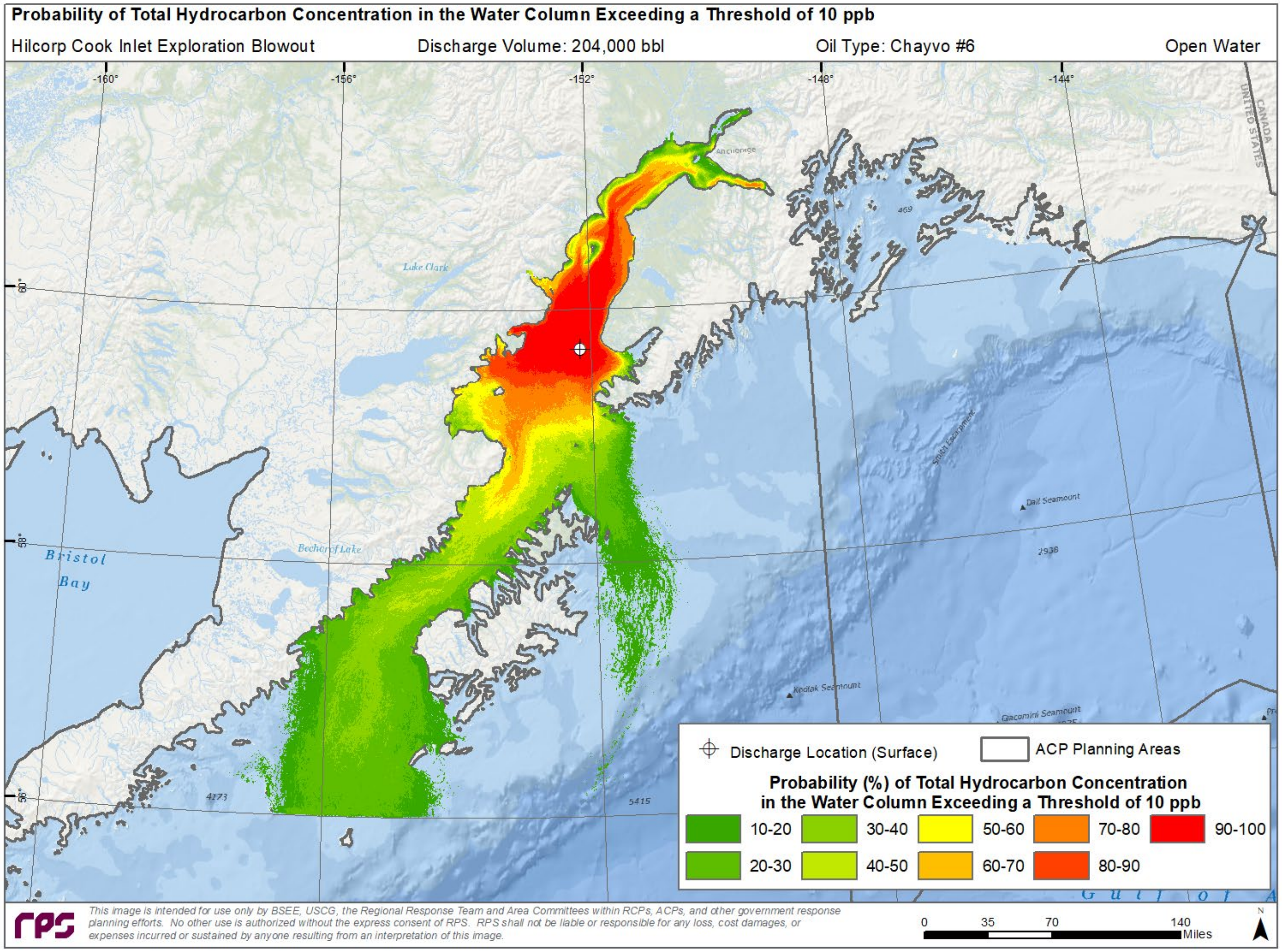

Figure 7. Probability Footprint for Total Hydrocarbon Concentration (THC) concentrations in the Water Column greater than the Ecological Threshold of 10 µg/L (~10 ppb). 10 ppb (µg/L) of whole oil (THC) corresponds to ~0.1 µg/L (~1 ppb) of dissolved Polycyclic Aromatic Hydrocarbons (PAHs) for fresh crude oils. This threshold can result in sublethal impacts to early life stages of fish and invertebrates in the upper ~20 meters of the water column if exposed to UV light.

The “worst case” deterministic simulation is a single oil trajectory run using the time period and ambient conditions that resulted in the greatest area of shoreline oiling. The simulation resulted in oiling in the following cumulative amounts:

- Swept Oiled Surface Area Exceeding 0.04 µm (Socioeconomic Impact) = 649,795 mi^2
- Swept Oiled Surface Area Exceeding 10 µm (Ecological Impact) = 632,653 mi^2
- Oiled Shoreline Exceeding 10 µm (Ecological Impact) = 2,492 mi
- Water Column Oil Exposure Exceeding 10 ppb Dissolved PAH (Ecological Impact) = 14,925 million m3
- Time to Shore = 27 hrs

These impact values are calculated considering no response measures are taken to secure the source of the spill or to contain, remove, or disperse oil at the scene.

Table 5. Mass balance at the end of the worst case deterministic simulation (% of the total volume of oil discharged*).

Total Oil Discharged	Surface	Evaporated	Water Column	Sediment	Ashore	Degraded
204,000bbl	5.3%	55.7%	2.2%	<0.1%	17.3%	12.6

*Important to note these values are not indicative of the maximum amount of oil in each compartment, but instead show the final amount of oil in each compartment.

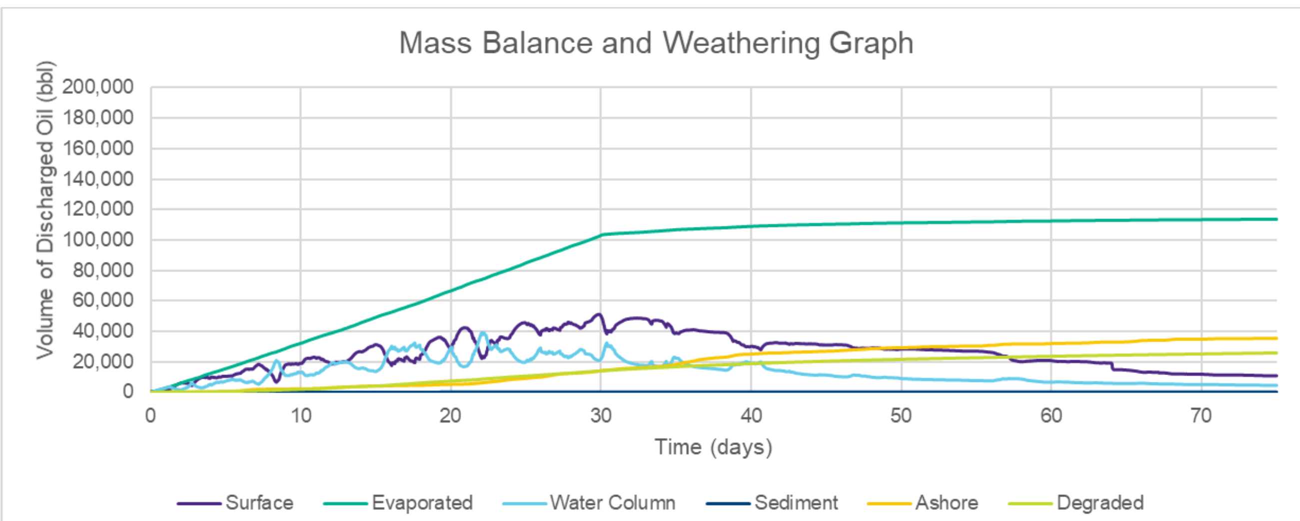

Figure 8. Mass Balance over Time for worst case deterministic simulation.

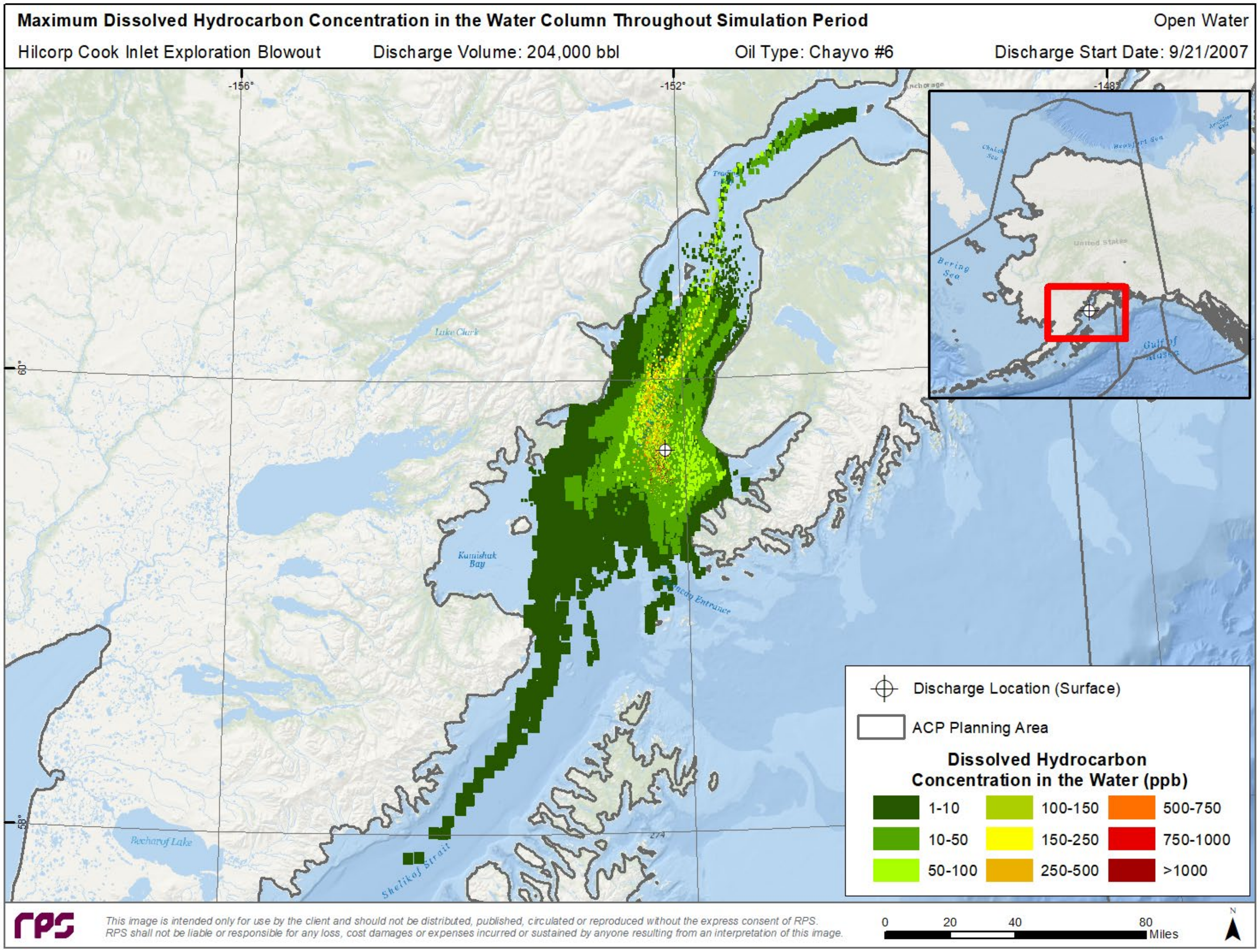

Figure 9. Cumulative Maximum Concentration of Dissolved Polycyclic Aromatic Hydrocarbons (PAH) within the water column at any time during the worst case deterministic simulation period. Dissolved PAH concentrations greater than ~10 µg/L (~10 ppb) could affect plankton in the upper ~20 m and impart sublethal to lethal effects on other water column biota (adult, juvenile fish, and invertebrates).

3.3 Response Planning Information

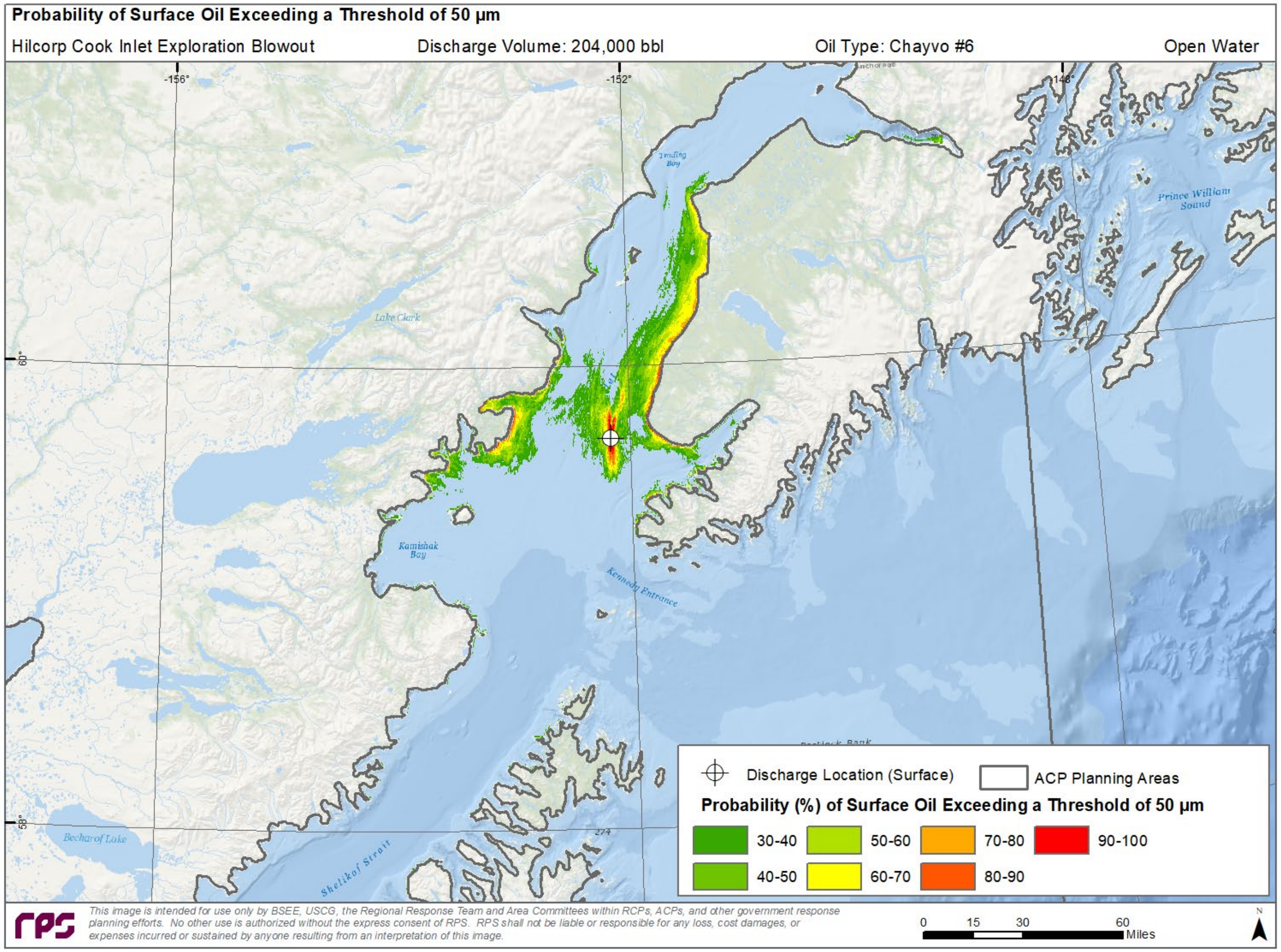

Figure 10. Probability Footprint for Surface Oil exposure greater than 50 µm. In this thickness range, oil will appear as a continuous to discontinuous patches of dark oil in quantities where high volume on-water mechanical recovery operations will be the most productive.

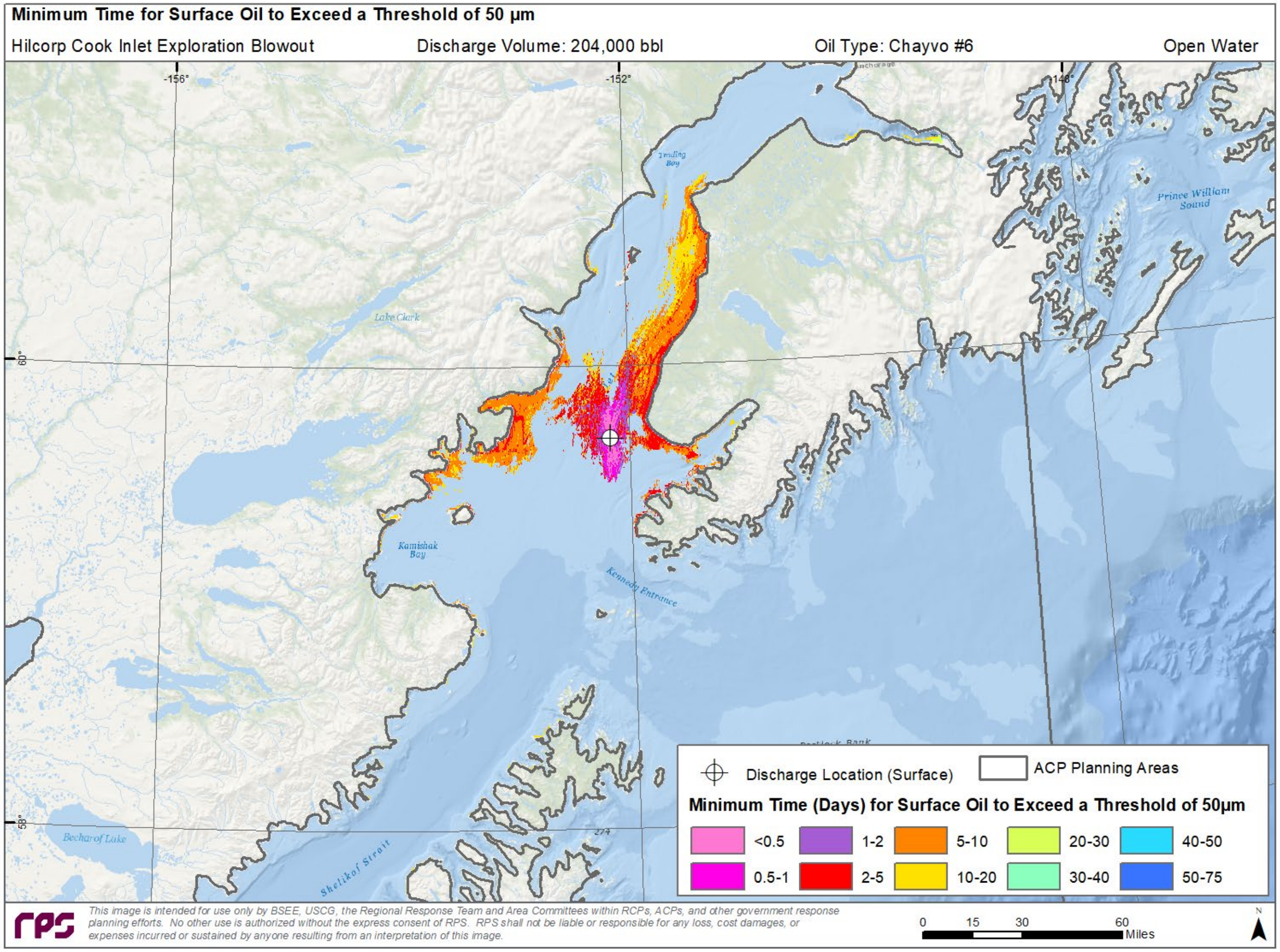

Figure 11. Minimum Travel Time for Surface Oil exposure greater than 50 µm.

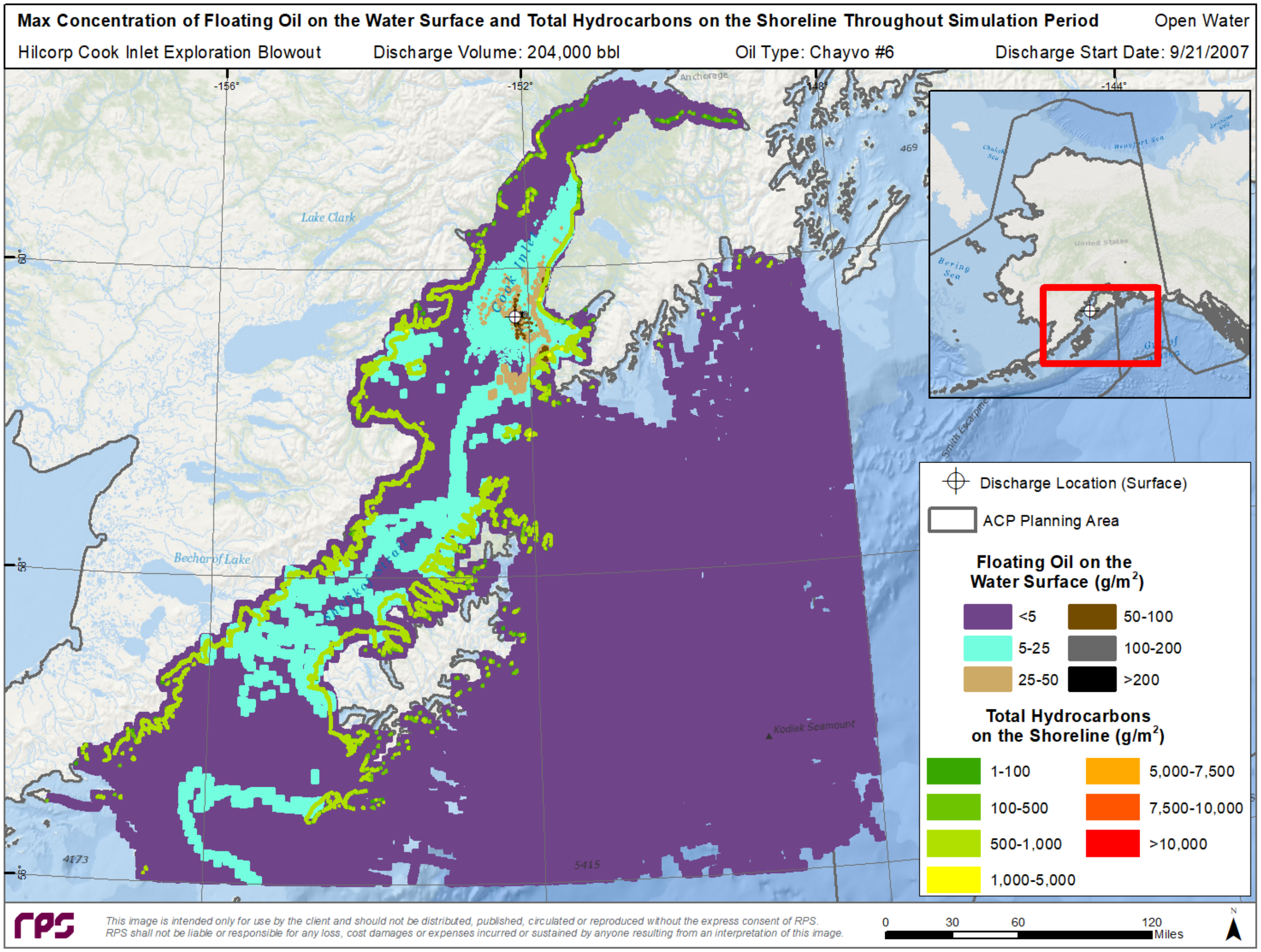

Figure 12. Cumulative Maximum Concentration of Floating Oil on the Water Surface and Total Hydrocarbons on the Shoreline at any time during the worst case deterministic simulation.

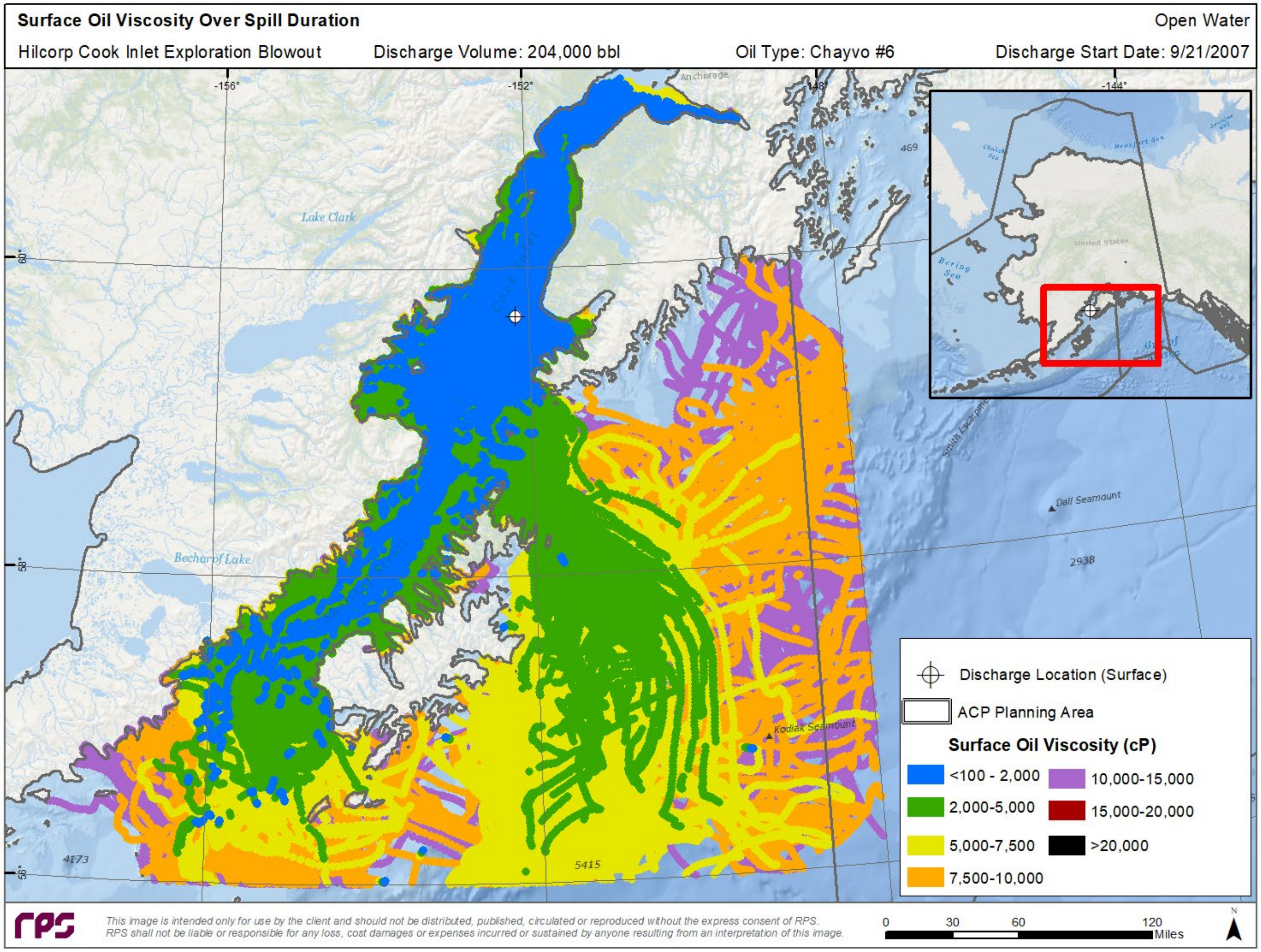

Figure 13. Cumulative footprint of exposure to surface floating oil greater than the minimum oil viscosity over a 75-day period for the worst case deterministic simulation. Viscosities greater than those mapped may be present at any location at any specific time in the simulation. This graphic provides a perspective of how oil viscosity may change as oil is transported away from the discharge site over time, and what areas may be amenable to dispersant operations where enough quantities of oil are present.

4 Cosmo A-1 Batch Spill

4.1 Scenario Description

The Cosmo A-1 WCD Scenario is a batch spill with the following key parameters:

Table 6. Scenario Key Parameters.

Discharge Depth (m)	Distance from Shore (NM)	Oil Type	Spill Type	Ice Coverage	Discharge Duration (days)	Discharge Flowrate (bbl/day)	Total Oil Discharged (bbl)
Surface	2.82	Heavy Crude API = 27	Surface Well Blowout	Open Water	1	800	800

4.2 Potential Oil Contact with the Environment and Resources at Risk

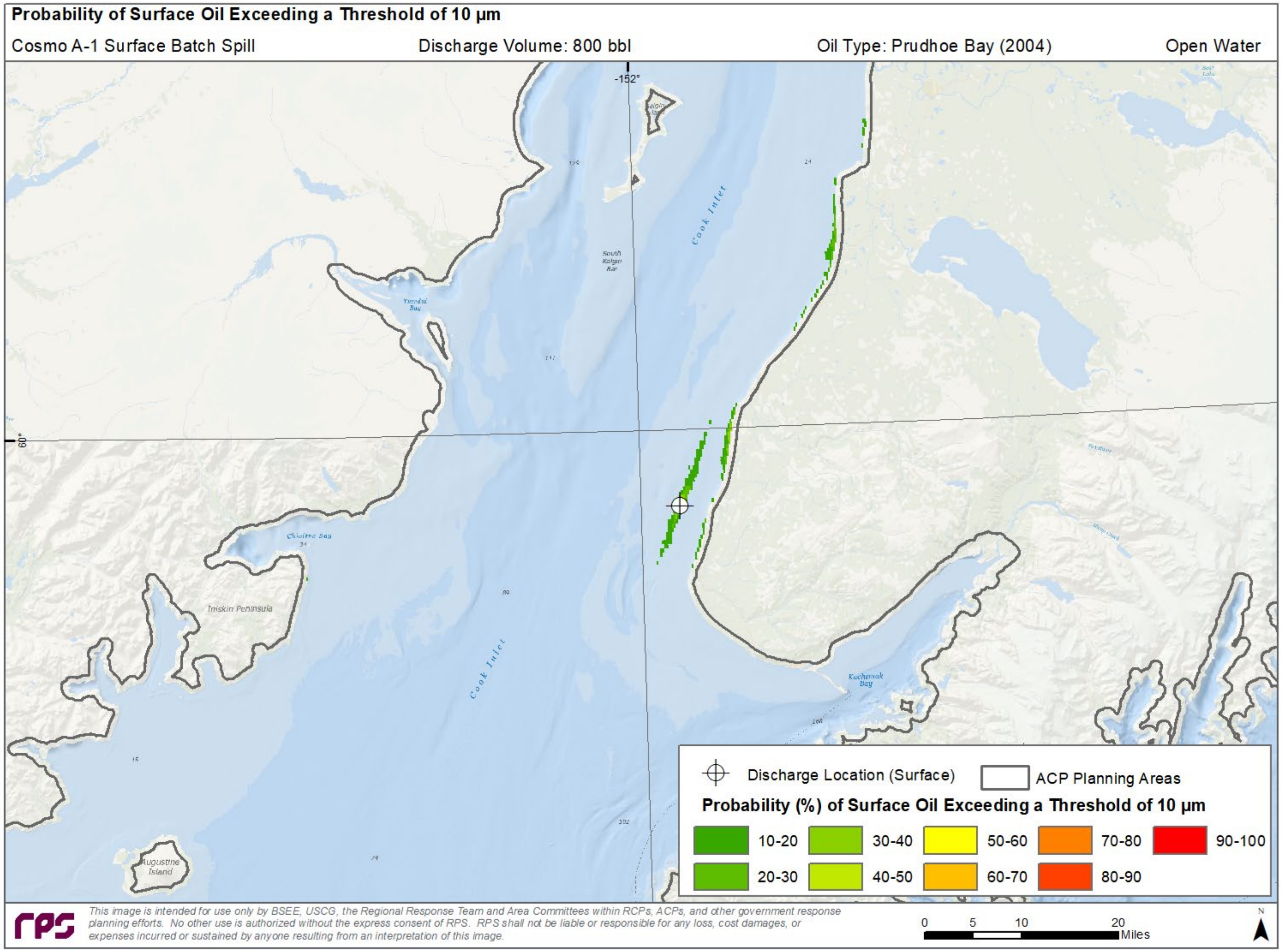

Figure 14. Probability Footprint for Oil on the Water Surface with Average Thickness greater than the Ecological Threshold of 10 µm.

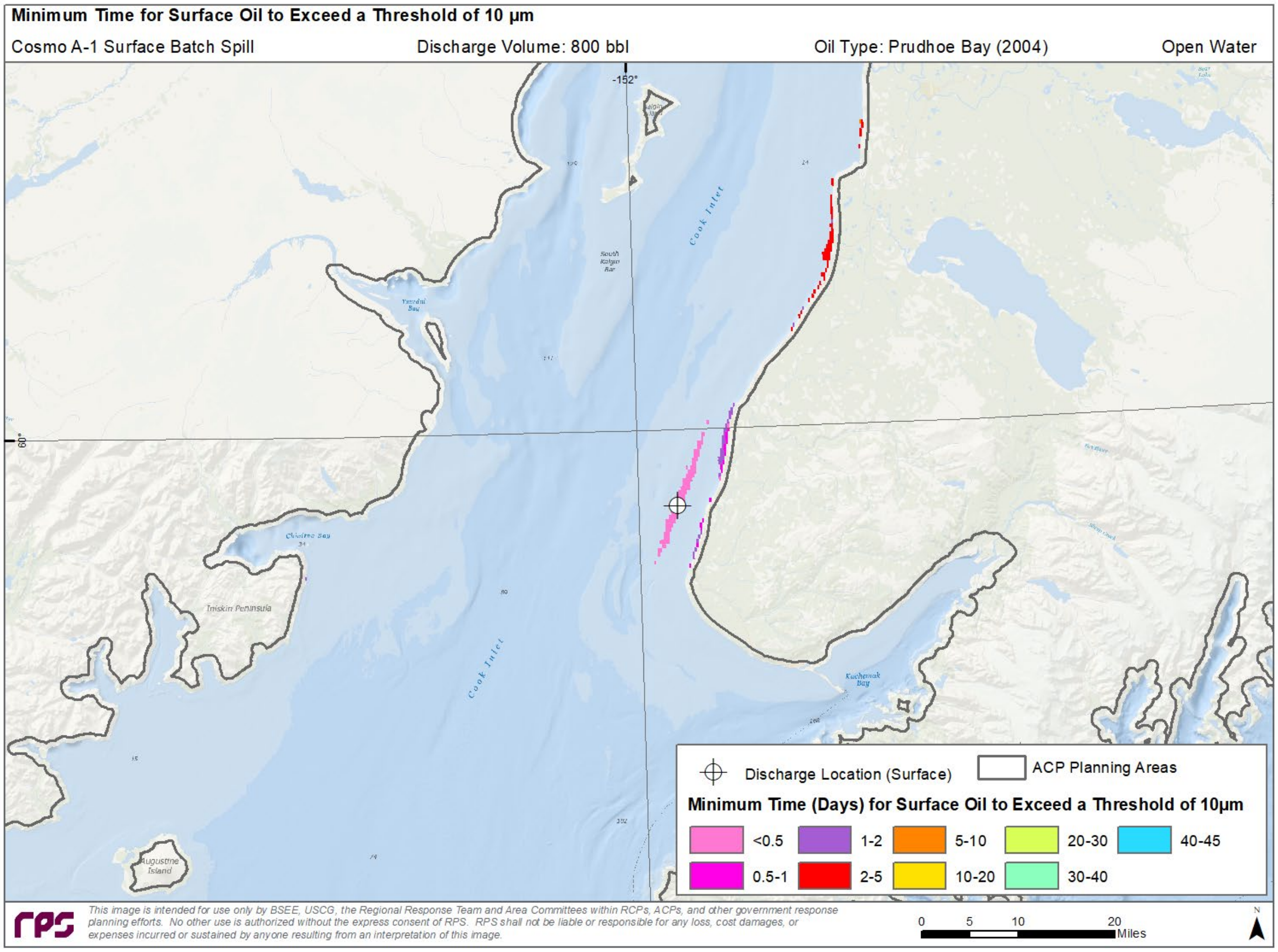

Figure 15. Minimum Travel Time for Oil on the Water Surface with Average Thickness greater than the Ecological Threshold of 10 µm.

Table 7. Oil Spill Stochastic Results – Predicted Shoreline Impacts.

Percentage of Simulations Reaching shore (%)	Percent volume of discharged oil reaching shore (%)		Time to Reach Shore (hours)	
	Maximum	Average	Minimum	Average
100	77	65	4.5	39.8

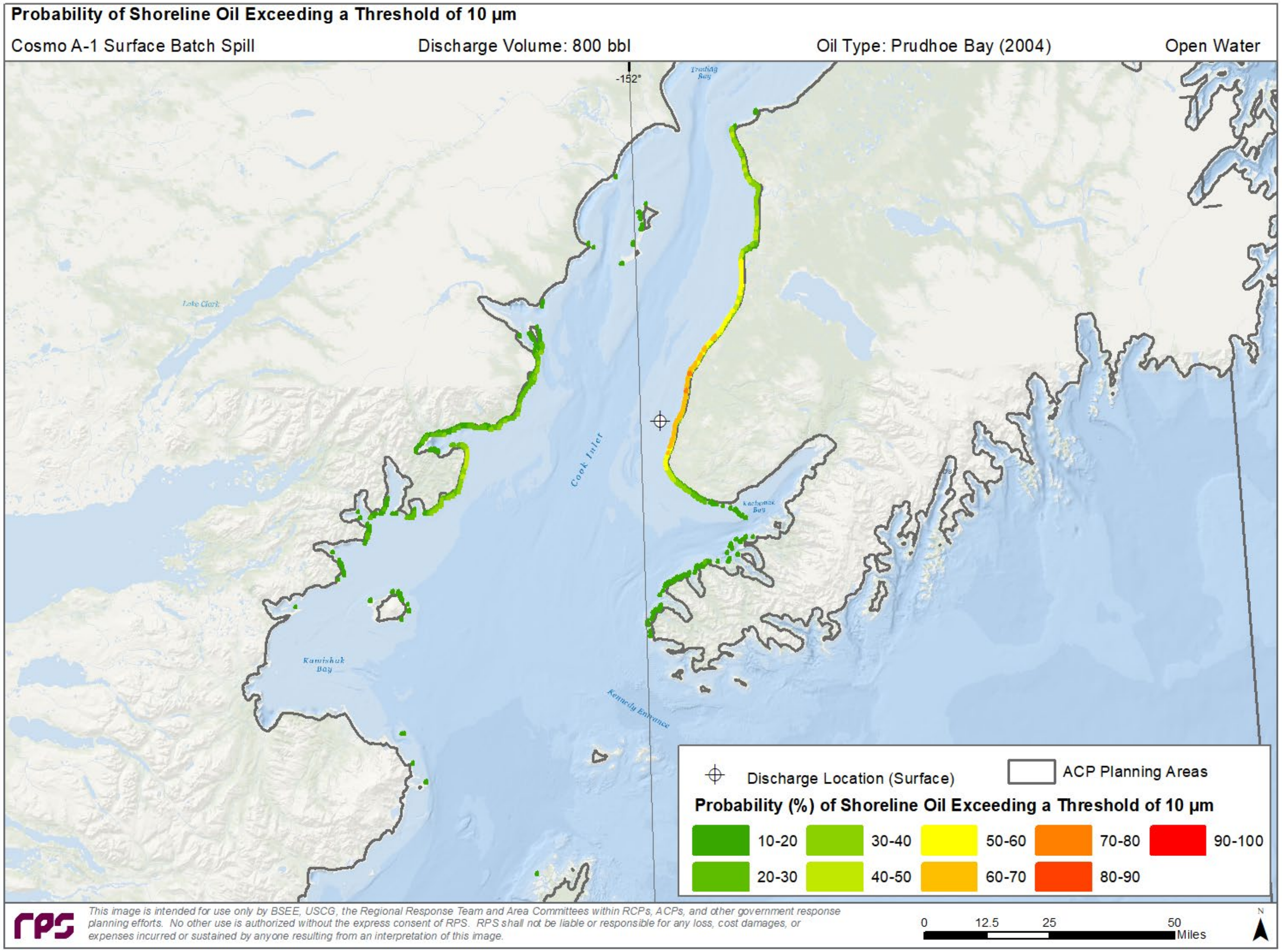

Figure 16. Probability Footprint for Oil on the Shoreline with Average Thickness greater than the Ecological Threshold of 10 µm. This thickness of oil may appear on the shore as dark stain or film. 10 µm is a conservative ecological screening threshold for potential sublethal effects on fauna and birds on the shoreline.

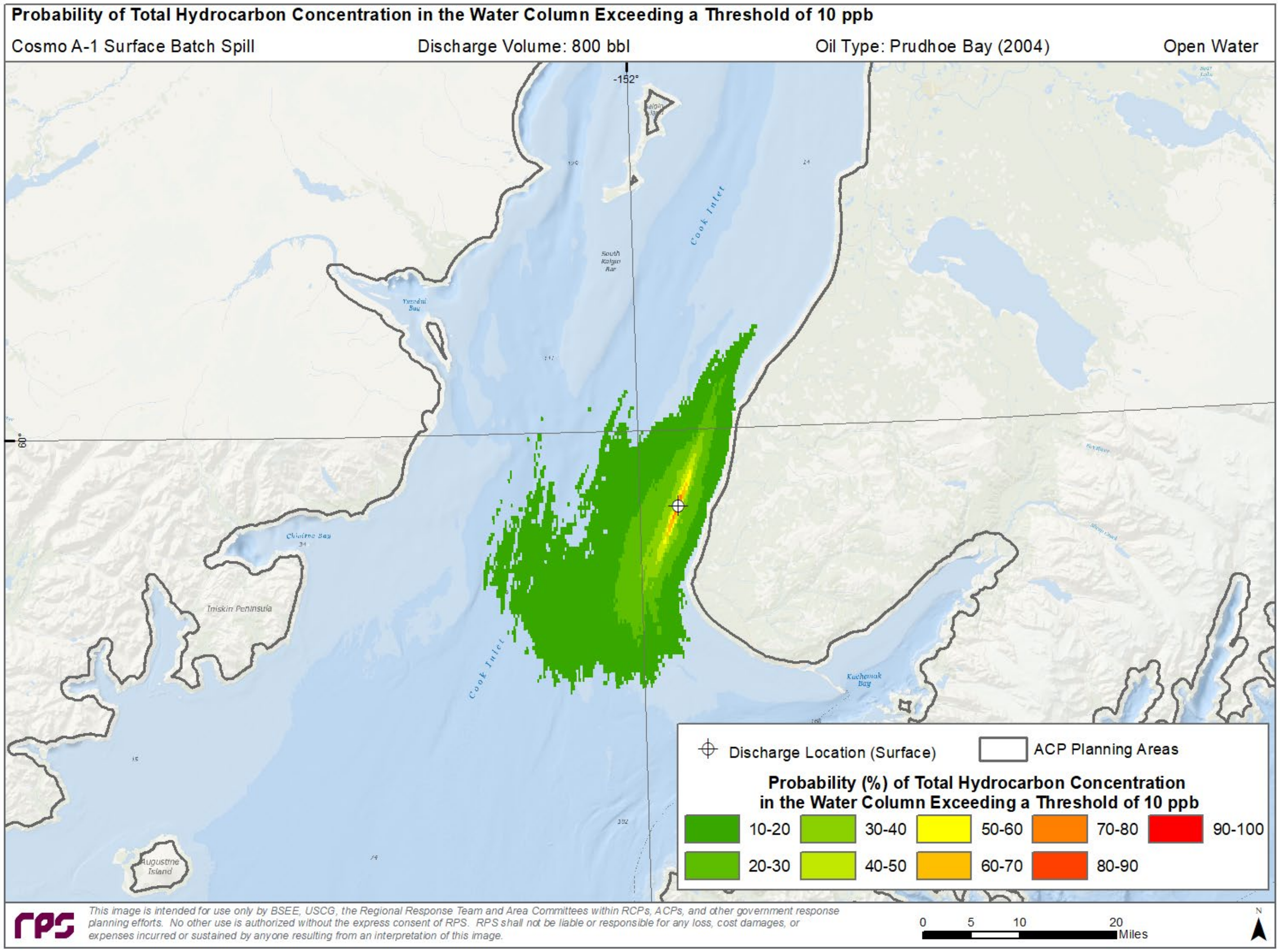

Figure 17. Probability Footprint for Total Hydrocarbon Concentration (THC) concentrations in the Water Column greater than the Ecological Threshold of 10 µg/L (~10 ppb). 10 ppb (µg/L) of whole oil (THC) corresponds to ~0.1 µg/L (~1 ppb) of dissolved Polycyclic Aromatic Hydrocarbons (PAHs) for fresh crude oils. This threshold can result in sublethal impacts to early life stages of fish and invertebrates in the upper ~20 meters of the water column if exposed to UV light.

The “worst case” deterministic simulation models is a single oil trajectory run using the time period and ambient conditions that resulted in the greatest area of shoreline oiling. The simulation resulted in oiling in the following cumulative amounts:

- Swept Oiled Surface Area Exceeding 0.04 µm (Socioeconomic Impact) = 2,250 mi^2
- Swept Oiled Surface Area Exceeding 10 µm (Ecological Impact) = 2,162 mi^2
- Oiled Shoreline Exceeding 10 µm (Ecological Impact) = 142 mi
- Water Column Oil Exposure Exceeding 10 ppb Dissolved PAH (Ecological Impact) = 21million m^3
- Time to Shore = 22 hrs

These impact values are calculated considering no response measures are taken to secure the source of the spill or to contain, remove, or disperse oil at the scene.

Table 8. Mass balance at the end of the worst case deterministic simulation (% of the total volume of oil discharged*).

Total Oil Discharged	Surface	Evaporated	Water Column	Sediment	Ashore	Degraded
800 bbl	<0.1%	30.6%	<0.1%	<0.1%	60.1%	9.3%

*Important to note these values are not indicative of the maximum amount of oil in each compartment, but instead show the final amount of oil in each compartment.

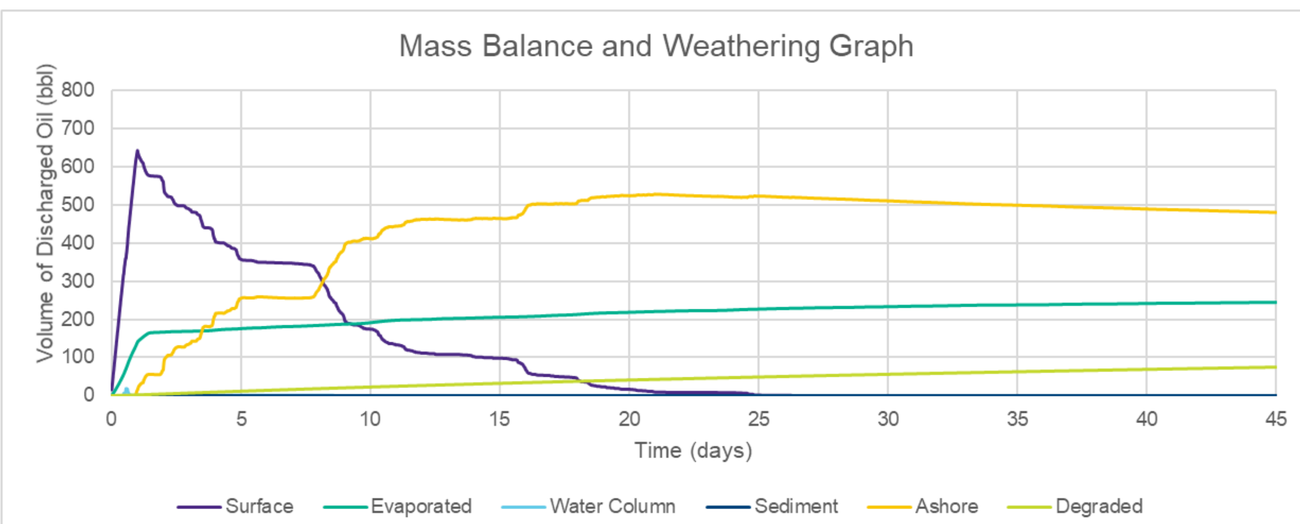

Figure 18. Mass Balance over Time for worst case deterministic simulation.

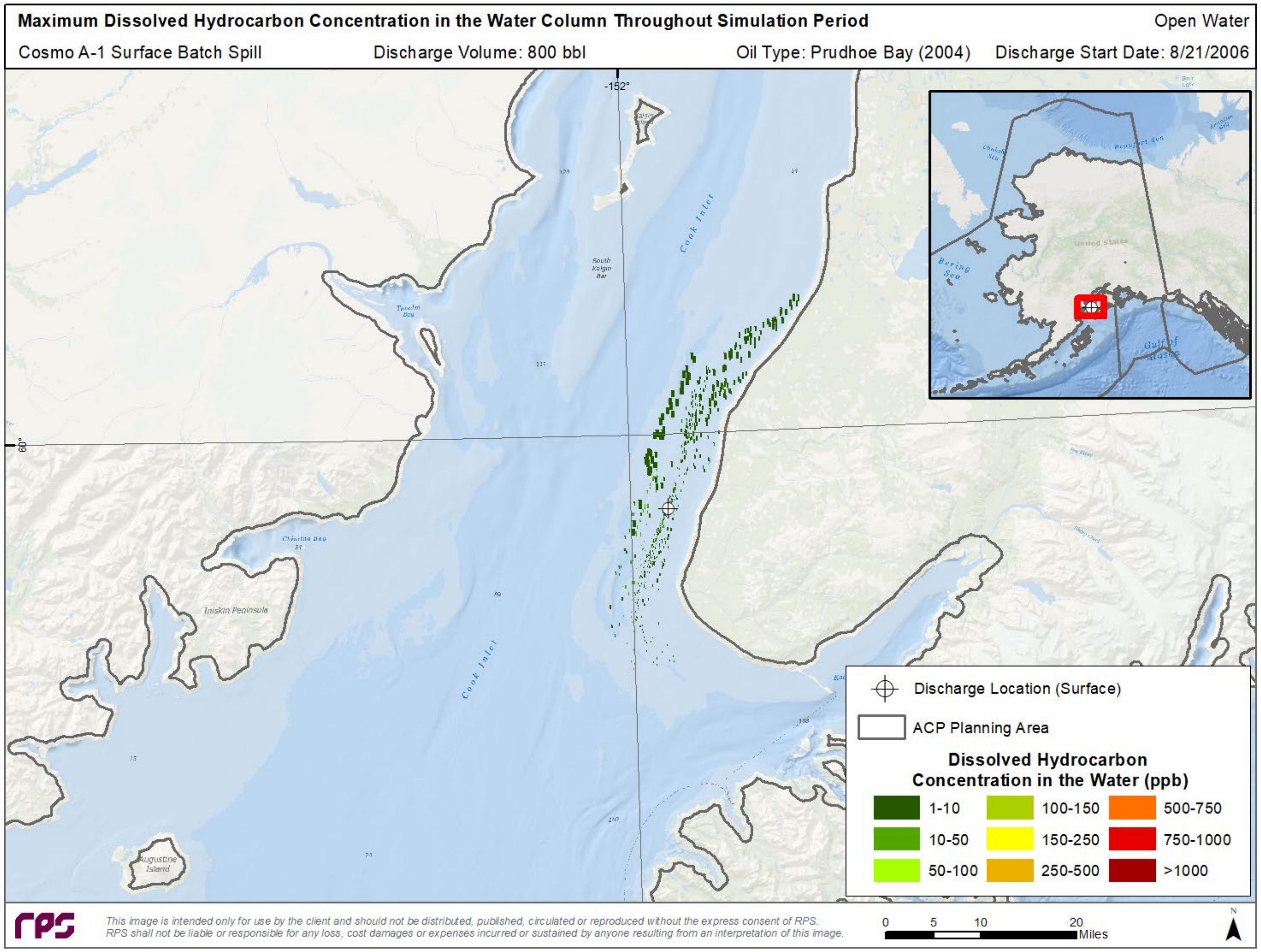

Figure 19. Cumulative Maximum Concentration of Dissolved Polycyclic Aromatic Hydrocarbons (PAH) within the water column at any time during the worst case deterministic simulation period. Dissolved PAH concentrations greater than ~10 µg/L (~10 ppb) could affect plankton in the upper ~20 m and impart sublethal to lethal effects on other water column biota (adult, juvenile fish, and invertebrates).

4.3 Response Planning Information

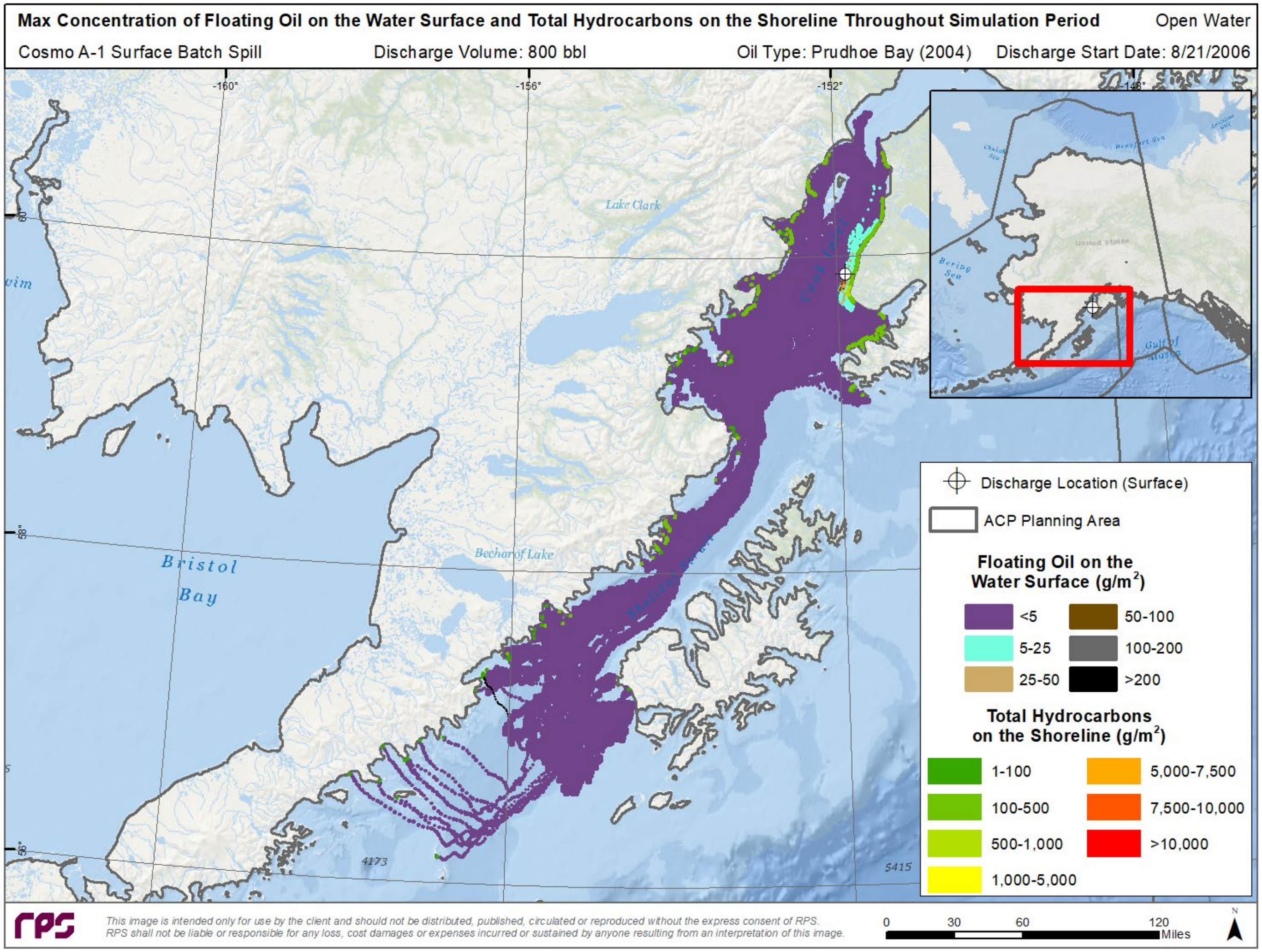

Figure 20. Cumulative Maximum Concentration of Floating Oil and Total Hydrocarbons on the Shoreline at any time during the worst case deterministic simulation.

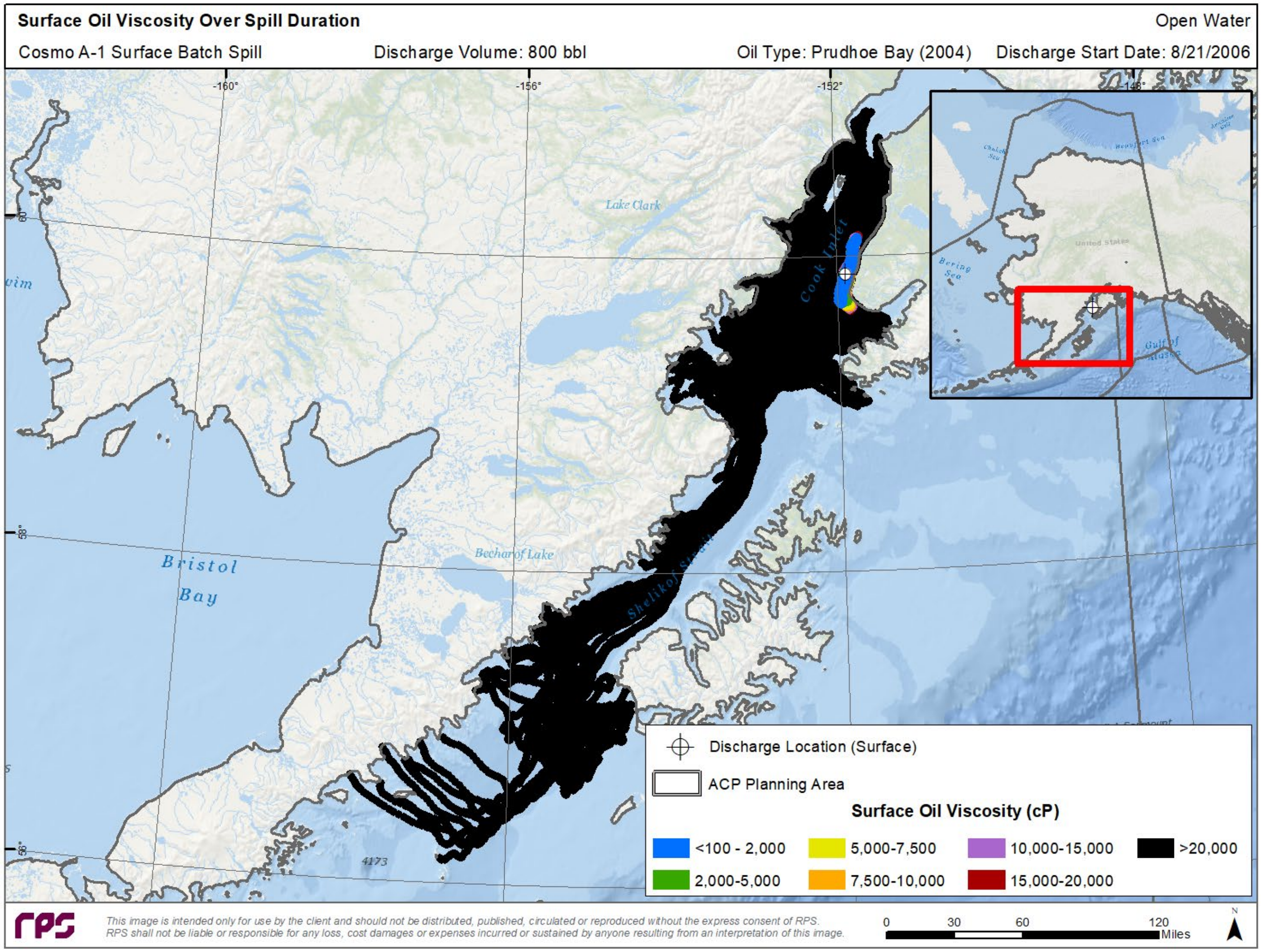

Figure 21. Cumulative footprint of exposure to surface floating oil greater than the minimum oil viscosity over a 75-day period for the worst case deterministic simulation. Viscosities greater than those mapped may be present at any location at any specific time in the simulation. This graphic provides a perspective of how oil viscosity may change as oil is transported away from the discharge site over time and what areas may be amenable to dispersant operations where enough quantities of oil are present.